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Kinetic Simulations of Intense Ultra-Short-Pulse Laser Light on Thin Targets*

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We investigate the interaction of high-intensity, short-pulse lasers with thin, solid-density targets using kinetic particle-in-cell simulations. The simulations are one-dimensional in space with three velocity components, and electron-ion Coulomb collisions are included. The plasma is initialized as a cold, fully-ionized plasma slab with sharp density jumps from vacuum to solid material. Our nominal case is a 100 nm thick aluminum target, illuminated by 400 nm wavelength light with a 100 fs full-width-half-maximum Gaussian time history.

When the peak laser intensity is $I=10^{18}$ W/cm^2, the fractional absorption is approximately 3% with mean electron energies of about 20 keV. At $I=10^{19}$ W/cm^2, a sizable population of high-energy (>100 keV) electrons appears, and the absorption increases to 7%. In this case, and at higher energies, trains of high-energy electron pulses can be seen in the plasma, separated by half the wavelength of the incident light wave; these electrons interact strongly with the background plasma through excitation of plasma waves. The absorption increases to 12% for $I=10^{20}$ W/cm^2, and at $I=10^{21}$ W/cm^2 it increases to 20%. At the higher intensities, some electrons reach several MeV.

The absorption, once the plasma reaches a few keV, is collisionless, and the mechanism appears to be the proposed by Kruer and Estabrook [1]. This mechanism relies on the pulsed nature of the electromagnetic ponderomotive force. The electrostatic confinement of the energetic electrons, characteristic of a thin target, is crucial to the enhancement of the absorption, as demonstrated by simulations in which the energetic electrons are absorbed at nearby boundaries. The expansion of the ions, although not large, also plays a role in enhancing the absorption.

Following the absorption of energy by the electrons, the ions are accelerated by the ambipolar field. For the 10^{20} W/cm^2 intensity, some ions are accelerated to more than 100 MeV (~0.1*c*). These ions may be useful for bombarding a secondary target.

We will show further results, varying target thickness, pulse length, pulse shape, and laser wavelength.

[1] W.L. Kruer and K. Estabrook, *Phys. Fluids* **28**, 430 (1985)

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